Effect of Conventional Heat and Thermosonication Treatments on Broccoli (*Brassica oleracea L.*) Total Phenolic Content

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☞Objective

To evaluated the effect of conventional heat treatment (70-90ºC) and thermosonication (60-90ºC; 42 kHz) on broccoli total phenolic content

☞Introduction

Phenolic compounds constitute one of the most important groups of natural antioxidants, owing to their diversity and extensive distribution.

In human health, phenolic substances are associated to protection against coronary heart disease, cancer and neurodegenerative diseases.

Fruits and vegetables are good sources of natural antioxidants, such as vitamins, carotenoids, flavonoids and other phenolic substances.

Phenolic content of vegetables is influenced by technological treatments.

Heat treatments are the most used methods for stabilising vegetables.

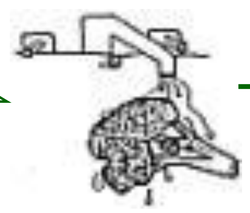
A growing interest on non-thermal preservation methods, that promote less quality losses, has been occurring.

☞ Materials & Methods

Fresh broccoli (*Brassica oleracea* L.)

Provided by an orchard near Lisbon

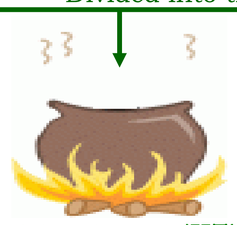
Cut into florets



Washed

Divided into three portions

Raw



Heat treatment (HT) in thermostatic water bath

[T: 70º to 90ºC; t: 0.08 to 16 min]

Thermosonication (TS) in an ultrasound equipment (Branson 3510)

[42 kHz; input power of 355 W; T: 60 to 90ºC; t: 0.08 to 18 min]

Phenolic Content Analysis

The total phenolic content of raw and processed vegetable samples (duplicates) was determined using Folin-Ciocalteu reagent, as described by Singleton & Rossi (1965).

Results were expressed as milligram gallic acid equivalents (GAE)/100g of fresh vegetable (FW).

Data Analysis

- Zero order kinetics model was used to describe phenolic content changes.

$$C = C_0 - kt \quad \textbf{(Eq. 1)}$$

- A one step non-linear regression was performed to all experimental data, using STAT 6.0 software.
- The rate temperature dependence constant was expressed by the Arrhenius equation

$$k = k_{ref} \exp\left[-\frac{Ea}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right] \quad \textbf{(Eq. 2)}$$

- **An analysis of variance (one way ANOVA with replication) was performed to determine significant effects on data due to blanching time-temperature conditions.**

☞ References

Leja, M., Mareczek, A., Starzynska, A., & Rozek, S. (2001). Antioxidant ability of broccoli flower buds during short-term storage. *Food Chemistry*, 72: 219-222.

Saltveit, M.E. (1998). Heat-shock and fresh cut lettuce. *Perishables Handling Quarterly*, 95: 5-6.

Singleton, V.L., & Rossi, J.A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American Journal of Enology and Viticulture*, 16: 144-158.

Oboh, G. & Akindahunsi, A.A. (2004). Change in the ascorbic acid, total phenol and antioxidant activity of sun-dried commonly consumed green leafy vegetables in Nigeria. *Nutritional Health*, 18(1): 29-36.

Turkmen, N., Sari, F., & Velioglu, Y.S. (2005). The effect of cooking methods on total phenolic and antioxidant activity of selected green vegetables. *Food Chemistry*, 93: 713-718.

Zhang, D., & Hamauzu,Y. (2004). Phenolics, ascorbic acid, carotenoids and antioxidant activity of broccoli and their changes during conventional and microwave cooking. *Food Chemistry*, 88: 503-509.

☞ Results & Discussion

Data on broccoli total phenolic content of processed green vegetables are recent and very limited. Table 1 presents literature and experimental values.

Table 1. Total *p*henolic content of raw broccoli (published and experimental data).

	Total Phenolic content
Leja, Mareczek, Starzynska & Rozek (2001)	56.2 mg/100g FW
Zhang & Hamauzu (2004)	34.5 mg/100g FW
Turkmen, Sari & Velioglu (2005)	1204.3 mg/100g dm
Experimental data	68.0±1.02mGAE/100g FW

Both treatments applied, heat treatment (HT) and thermosonication (TS), affected the total phenolic content as process intensity increased (Fig 1 and 2).

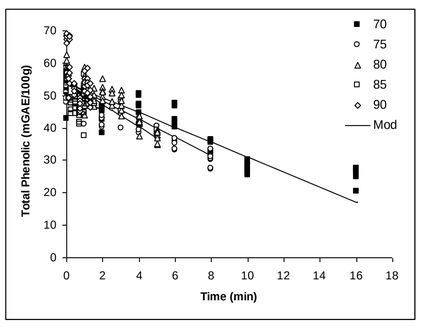


Fig 1. Effect of HT on broccoli total phenolic content. (--) model predicted data.

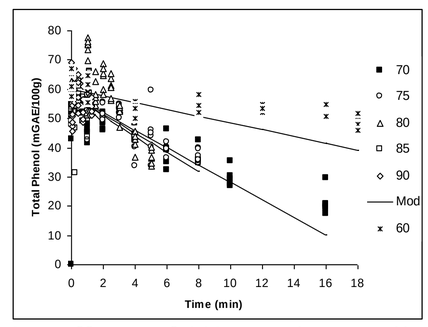


Fig 2. Effect of TS on broccoli total phenolic content. (--) model predicted data.

HT caused a significant decrease ($p<0.05$) of total phenolic. On the other hand, TS at temperatures between 75 to 85ºC and short times, caused a significant increase ($p<0.05$) in total phenolic content.

Similar results were reported by Oboh & Akindahunsi (2004), in different green leafy vegetables, and Saltveit (1998) in lettuce treated with different technologies.

At each different temperature applied, significant differences ($p<0.05$) were observed in the total phenolic content between HT and TS (Fig 3a and b).

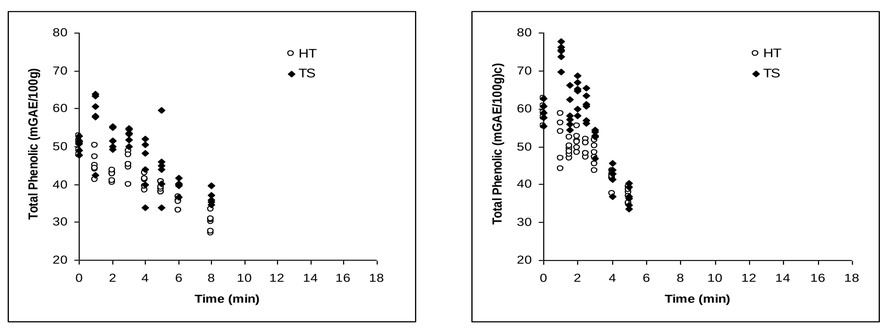


Fig 3: Comparative effect of HT and TS on total phenolic content: **a**) at 75ºC and **b**) at 80ºC.

Estimated kinetic parameters for both treatments are included in Table 2.

Table 2. Kinetic parameters of total phenolic content changes in processed broccoli, using HT and TS.

Kinetic parameters	Heat treatment	Thermosonication
Activation energy (Ea)	22.5±10.7x10^3 Jmol^{-1}	79.5±7.7x10^3 Jmol^{-1}
Reaction rate ($k_{T=80ºC}$)	2.4±0.2 min^{-1}	3.8±0.4 min^{-1}

As it can be observed, the degradation process of total phenolic content became more heat labile when TS was applied (larger activation energy).

☞ Conclusions

Conventional blanching and thermosonication treatments lead to significant broccoli total phenolic content changes.

Moderate thermosonication treatment might be considered has an useful tool for improving broccoli health properties, as long as it provide the required enzyme inactivation.

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